RADIO SYSTEM DESIGN TOOL

WHITE TIGRESS (BABY)- WTb

- a shortened version -

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THE RADIO SYSTEM DESIGN TOOL – *"WHITE TIGRESS (BABY)" - WTb*

The Radio System Design Tool "*WTb*" was created as a result of a long standing work of a large number of authors in the field of designing radio-systems. The title stems from the basic intentions of the authors: to develop a complex and a quality system for designing various types of radio-systems and the system to be modular and fully open for the superstructures according to specific requests of particular types of the radio-systems. The title suggests that such a package is rare in its class (*White Tigress)* and that it is developing continuously (*Baby).* Within the framework of the package *WTb,* the linking of the authors' theoretical knowledge and practical experiences was done with success, having in view that all the prediction models were tested in practice, all coefficients adjusted in real measuring conditions and the complete package was professionally used in an extended period of time.

It is to be emphasized that a large number of bigger or smaller radio-systems was designed in practice applying the package *WTb.* Some designs of importance for which *WTb* was used last few years or is used now are:

- The main project of the Paging system of Serbia.
- The preliminary projects of the GSM/UMTS systems of the cellular telephony TELEKOM SERBIA & VIP MOBILE SERBIA.
- Over two hundred technical documentations of GSM/UMTS base stations (over 20 000 trasceivers) and radio-rellay links for TELEKOM SERBIA & VIP MOBILE SERBIA.
- The preliminary project of a network of cellular radio-links of Electrical industry of Serbia.
- The preliminary project of a network of cellular radio-links of the Electrical industry of the Serbian Republic.
- The preliminary project: The selection of the location for the new terrestrial satellite station of TELEKOM.
- The preliminary project with the elements of the main project of the business cellular radio-telephone system of JKP Belgrade water supply and sewerage system.
- The preliminary project of the proposal of the GSM system of the cellular telephony of the Montenegro.
- The preliminary project of the proposal of the GSM system of the cellular telephony of the Serbian Republic.
- The study of the development of Electrical distribution Belgrade.
- A concept solution of the dispatcher system for monitoring and controlling the production in the copper mine -Majdanpek.
- Over three hundred technical documentations of TV and FM radio-diffusion stations, radio-rellay links and business radio-systems.
- and so on.

On the other hand, *WTb* is used and is intensively used in scientific-research activities of the authors and their associates, too. For example, this package was intensively used in the elaboration of two Master's theses and a great number of diploma final reports, several scientific papers were published in leading international and prestigious national periodicals or presented with success at national and foreign scientific conferences, etc.

Further text presents the outline surveys of basic units of the package *WTb*. Additionally, the survey of the databases was provided with which *WTb* is presently connected having in view the fact that in the process of designing modern radio-systems databases are of no lesser significance than the algorithms using them.

l. Presentation of program modules within the framework of the program package *WTb*

The program package *WTb* is a PC-application realized within the framework of the operating system Microsoft Windows. As already stressed, *WTb* has been permanently developing. At the moment several specific parts are clearly distinguished within the framework of this program package:

- program module for the terrain analysis (using the maps with the scale 1:25,000 and the digital base about the height of the terrain),
- progam module for predicting the level of the electrical field in macrocell radio networkss,
- program module for predicting the level of the electrical field in microcell and indoor environments,
- program module for measuring the level of the electrical field and/or the signal level,
- program module for the presentation and analysis of the measuring results,
- program module for the analysis and synthesis of cellular radio networks,
- program module for the automatic frequency planning within the framework of cellular radio networks,
- program module for calculating the visibility zone from the known location,
- program module for designing microwave digital radio-relay links,
- program module for designing satellite links,
- program module for automatic inclusion of the diagrams of the antenna radiation and antenna systems.

Using **the program module for the analysis of the terrain by applying the maps of the scale 1:25,000 and the digital base on the terrain altitude**, it is possible to perform simply and fast the analysis of the microlocation from the point of view of setting a potential transmitter or a base station. Then it is possible to request the automatic drawing of the terrain profile from a given transmitter position of the cursor position. On the drawing of the terrain profile the geographic position of the transmitter, geographic position of the cursor, the distance, the azimuth and the elevation are automatically written down. The illustration of this program module is given in Fig. 1.

Within the framework **of the program module for predicting the electrical field level in macrocell radio systems** several popular methods for the prediction of the electrical field level were realized: ITU, CLA, Okumura-Hata's and Lee's model. Also, the original model of the prediction with the use of neural networks - ANN was realized. In all the mentioned models, the basic models were superstructured by using the base on the exploitation of the soil and the results of extended measurements carried out on Serbian spaces for several frequency ranges of particular interest.

The prediction of the electrical field level can be made, in two ways within the framework of *WTb*:

- *A classical manner (according to profiles); the prediction of the electrical field level is made on a given number of directions starting from the transmitter location.* For a given level of the field which is protected, a radio-shade zones and the zones of covering the radio-transmitter are determined. Such a way of prediction is suitable in the systems when a single radio-transmitter is considered (for example TV or FM radio-diffusion). Apart from that such a manner of prediction of the electrical field level is usually required by a majority of national administrations in the world. Fig.2 illustrates this manner of prediction of the electrical field level.

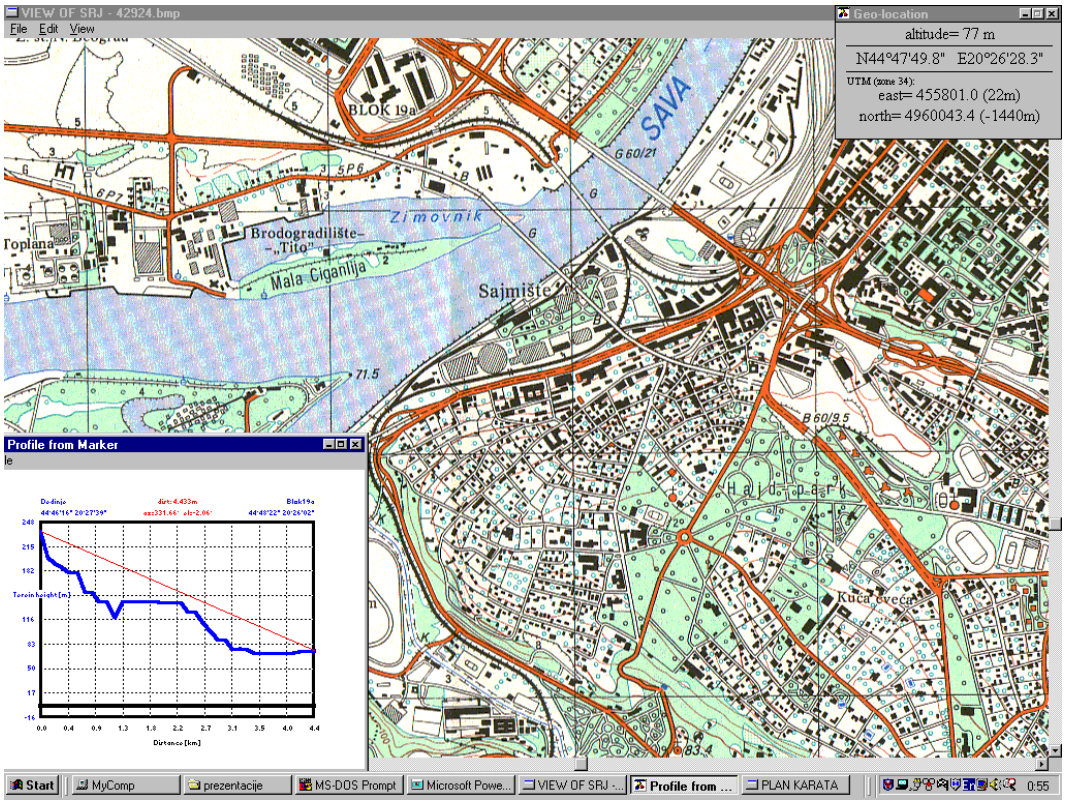

Fig. 1. *WTb* -the illustration of the programme module for the terrain analysis using the maps 1:25,000 and the digital 3D terrain elevation database

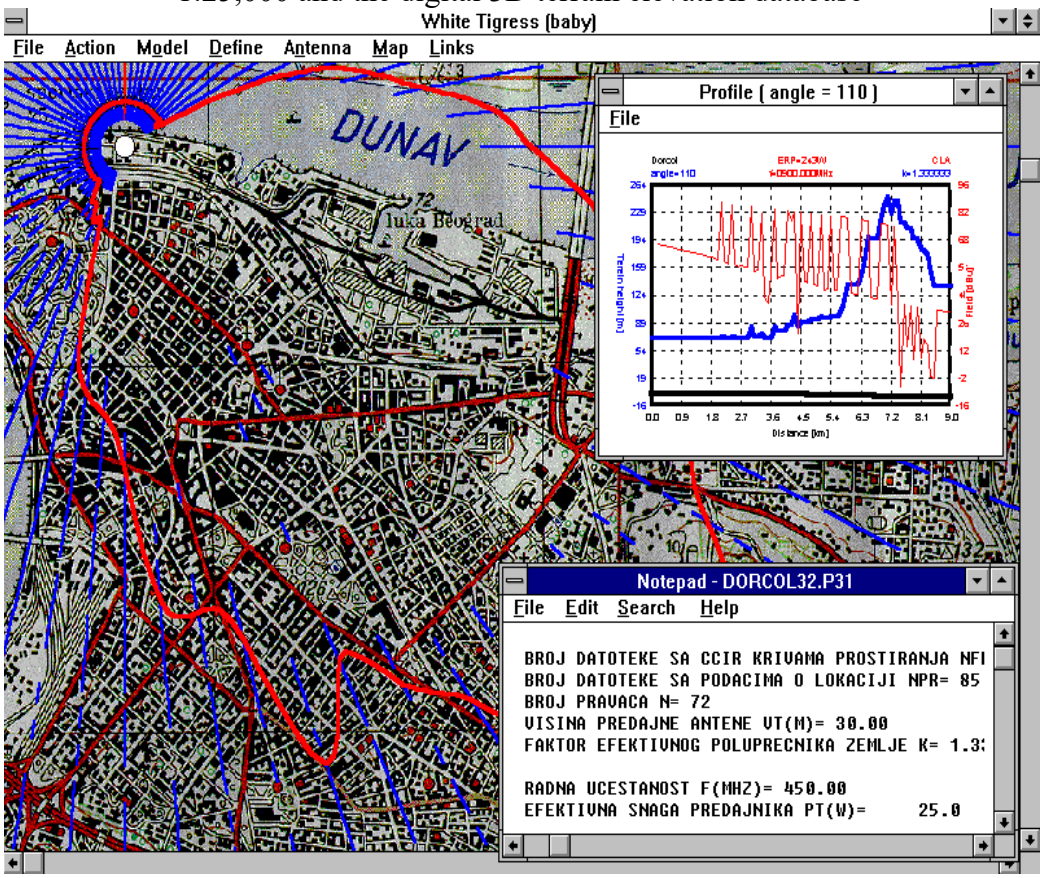

Fig. 2. *WTb*-illustration of the program module for predicting the electrical field level in a macrocell ("prediction according to profiles")

- *Prediction of the electrical field level calculated for every elementary part of the database on the terrain.* Within the framework of this manner, the prediction results are marshalled into a rectangular matrix for every transmitter, so that the analysis of the mutual functioning of two or more transmitters can be relatively easily done. Such a prediction way is of essential significance for designing a modern cellular system; it makes possible to realize maximal possible capacity of the system with respect to the traffic. The illustration of the program module realizing such a manner of prediction is displayed in Fig. 3.

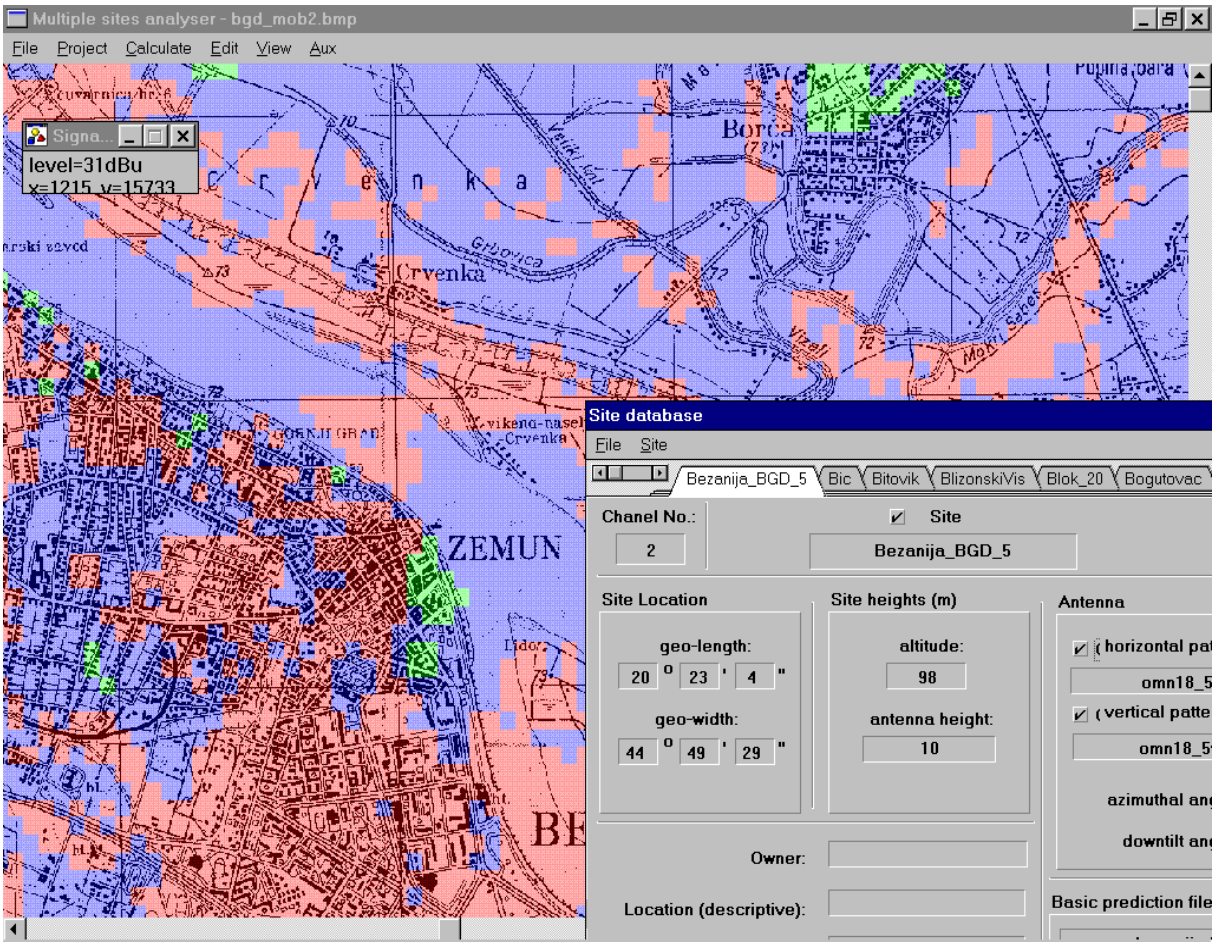

Fig. 3. *WTb* - the illustration of the program module for predicting the electrical field level in the macrocell ("prediction for every basic element of the base")

The prediction of the electrical field level in microcell and indoor environments was realized in the framework of the particular program module. The electrical field level prediction in the microcell is grounded on an automatic analysis of digitalized aerial photographs or on the precisely modelled surrounding of the microcell. As the prediction methods the improved variant of the popular *Lee* model for a microcell and the model using a neural network were implemented. On the basis of the results of extended measurements of the electrical field level the models were adapted to our conditions.The model for predicting the electrical field level in indoor surroundings is based on the neural networks principles. The neural network in its first step is "instructed" over the measured data and then it is used for the prediction of the electrical field level. This model was also developed in our conditions.

Within the framework of the program package *WTb* two types of the measuring systems were developed: **1. an automatized system for measuring the electrical field level stemming from the test transmitter and 2. an automatized system for measuring the signal level of the active GSM system.** The first type of measurement is carried out in the processes of adjusting the prediction model and determining correction factor when high reliability and accuracy are required. The basis of the measuring system consists of the measuring receiver of high sensitivity (having fast analogous and digital outputs) and a particularly calibrated measuring antenna. In the course of measurements the automatic positioning of the measuring vehicle is made by the GPS receiver. The automated system for measuring the level of the signal of the active GSM system enables the analysis of the quality of the GSM system in operational work. The measuring system makes possible a parallel measurement of the level of the signal of the active and adjacent servers, the measurement of the signal level at the requested channel, as well as the measurement of other additional parameters.

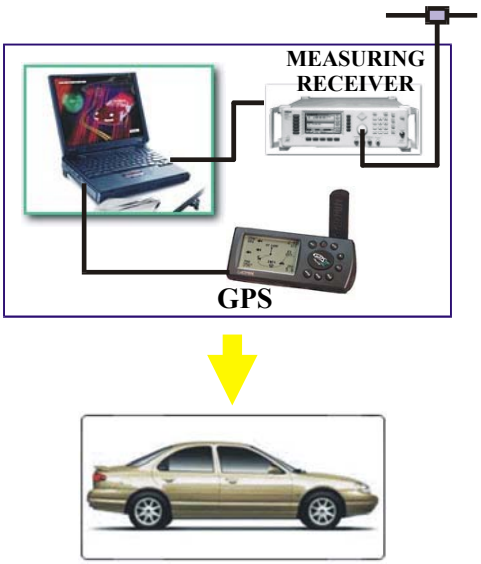

Fig. 4. The block scheme of the measuring system for measuring the electrical field level stemming from the test transmitter

The program module for the presentation and the analysis of the measuring results enables the survey of the measurements made on the geographic map. The base for geo-reference are the data used from the GPS receiver or the markers introduced during measurings. The analysis of the data measured implies the statistical analysis both within the framework of micro and macro zones. This part of the program module enables also the automatic comparison of measuring results and prediction results on the basis of which the correction factors of some models are obtained in order to increase to the maximum the accuracy of the model. The illustration of this program package is displayed in Fig.5 (the presentation of particular measuring results) and 6 (the presentation of imbedded values on the maps 1:25,000).

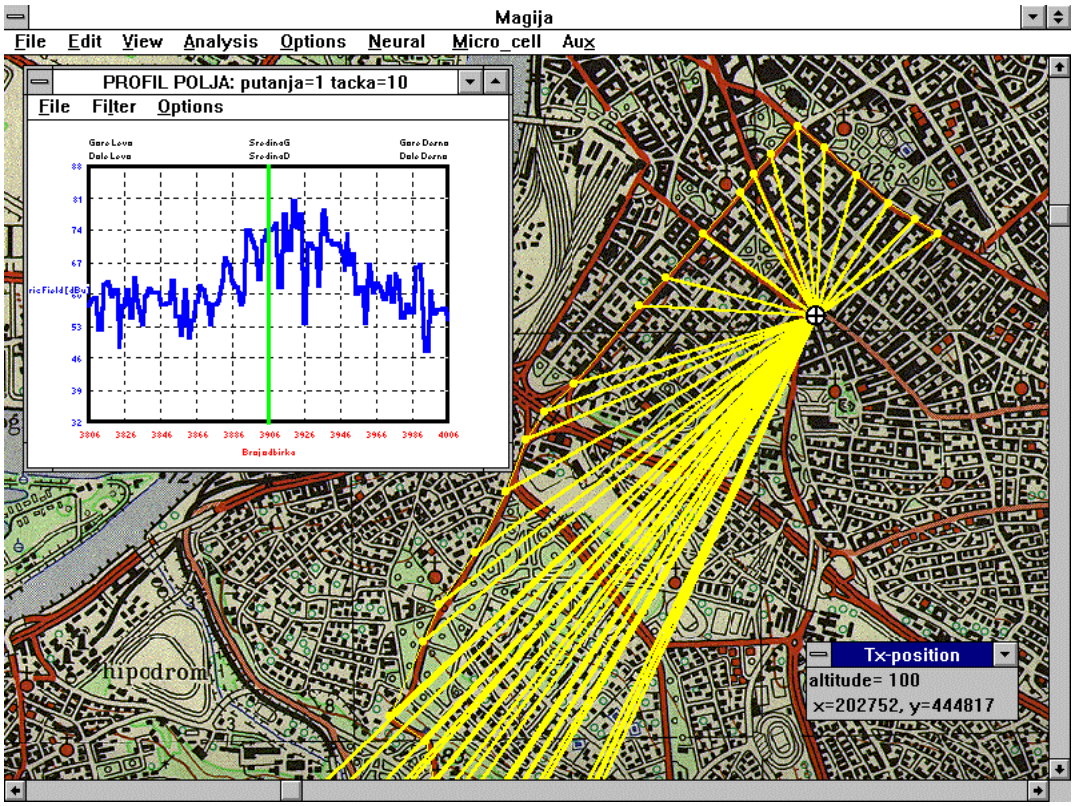

Fig. 5. WTb - the illustration of a program module for the presentation and the analysis of the measuring results of the electrical field level (the survey of some particular measuring results)

Program module for the analysis and synthesis of cellular radio networks enables the analysis of a common work of a large group of transmitters, i.e. of multi-sectorial and multichannels base stations within the framework of a complex cellular system. This analysis primarily implies the calculation of a summary covering of the territory by the entire system, the calculation of the co-channel interference, the calculation of adjacent channel interference and the calculation of the service zone of every cell. The illustration of this program module is given in Fig. 7.

For the needs of cell planning, the **program module for automatic generation of the frequency plan** was developed. The main ideas of the original algorithms could be summarized as follows:

- The configuration of the cellular radio network should be known.
- The requests with respect to the traffic capacity should be defined.
- The main idea is to find an optimized space and frequency distribution of disposable radio-channels in such a way to minimize the interference in the system.
- The process is based on electric field level prediction results.
- There is a fully automatic determination of cell neighbours.
- The handover parameters are taken in consideration.
- QoS parameters weights can be freely changed.
- The planing process is fully automatic.
- There is a possibility to predetermine some resorces within the system.

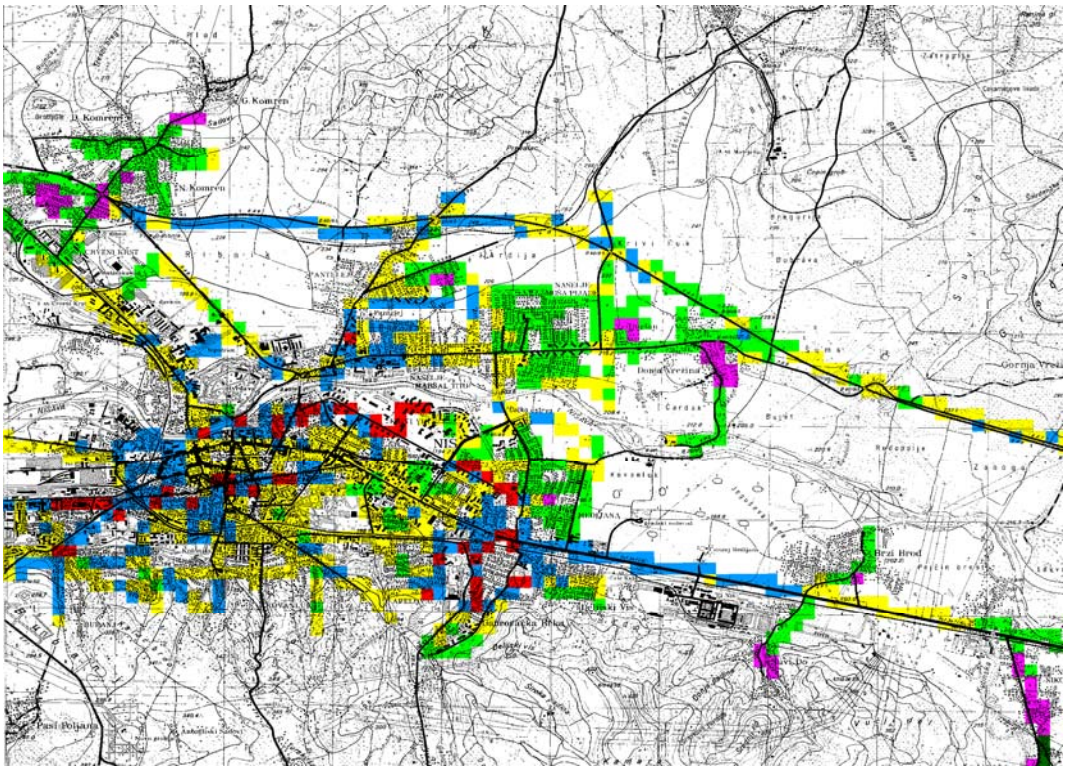

Fig. 6. WTb - the illustration of the program module for the presentation and the analysis of the imbedding results of the measuring of the electrical field level (presented on the maps 1:25,000).

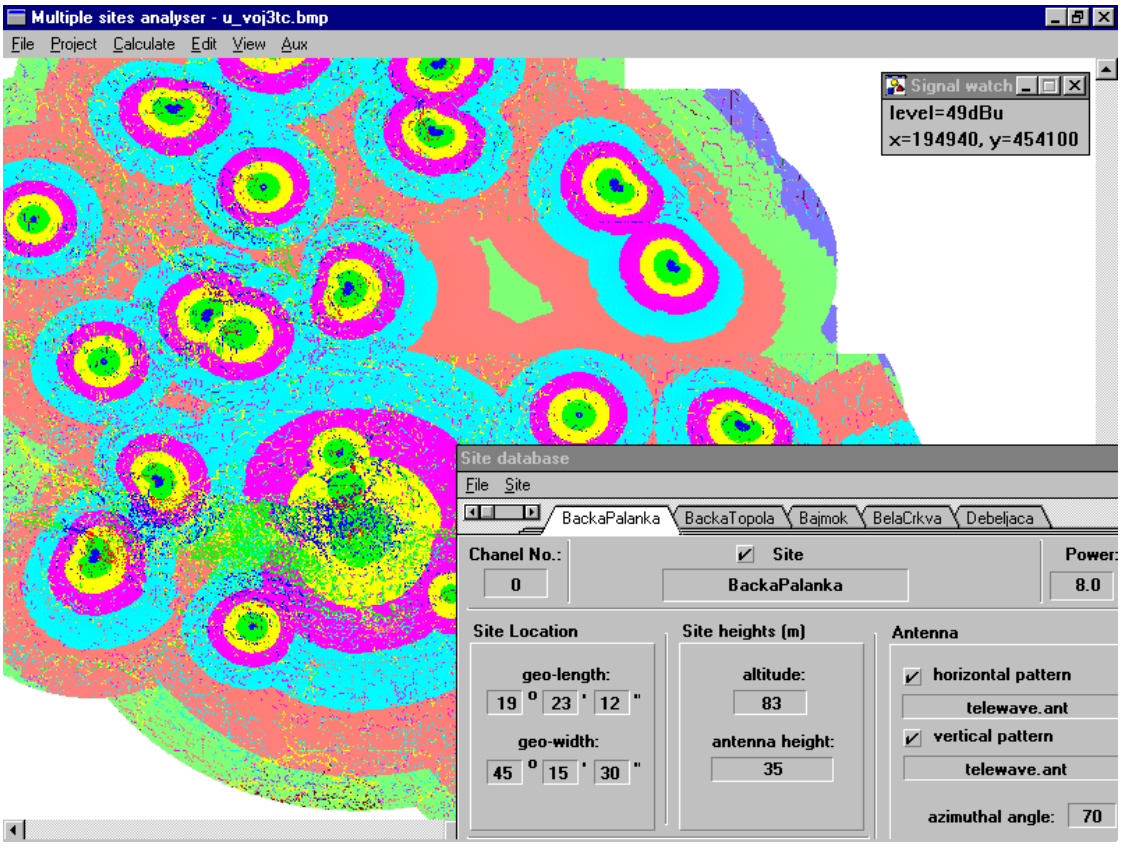

Fig. 7. *WTb* - the illustration of the program module for the analysis and syntheses of cellular radio-systems

Within the framework of **program module for designing microwave digital radio relay links** the standard ITU procedure for designing digital radio-relay links was realized.

Within the framework of **the program module for designing satellite links** an assembly was developed for determining elevation obstacle-free angles in some directions. As a separate entity an algorithm was realized for automatic research of the territory, i.e automatic determination of the location where the optical visibility conditions to the requested number of potential interferers were not satisfied.

The program module for calculating the visibility from a particular location **enables a simpler analysis of the possibility of connecting the transmitter location (base station) with the transmitting system.** Fig. 8 displays the illustration of this program module.

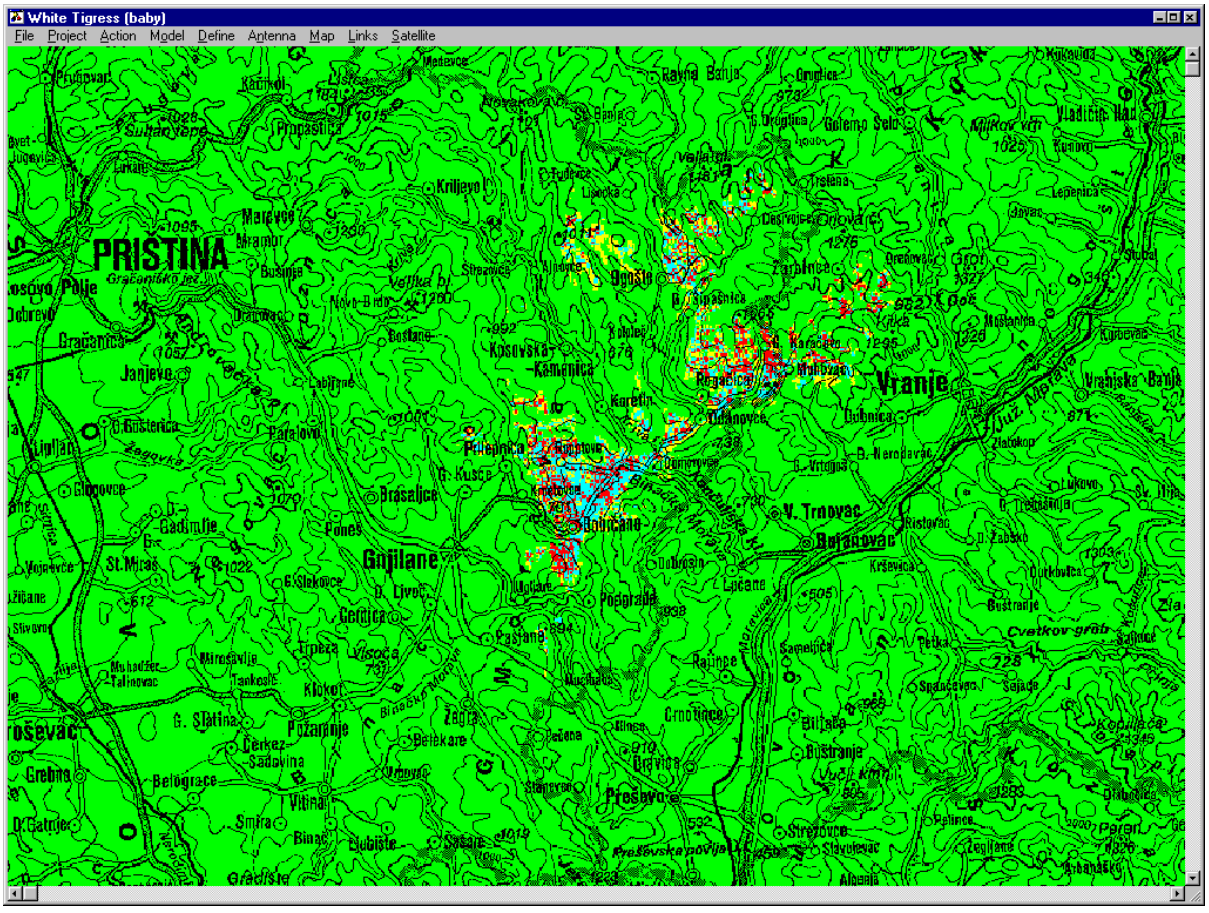

Fig.8 *WTb* -the illustration of the program module
for the calculation of the visibility from a particular location.

Having in view the fact that the manufacturers of antenna systems usually supply only the antenna radiation patterns in two orthogonal planes, an algorithm for the interpolation of the diagram of the antenna radiation in the directions not belonging to orthogonal planes for which the radiation diagram was developed and applied.

Apart from the quoted program modules there is a series of smaller program entities for the realization of minor auxiliary functions, i.e. small things of great importance.

2. Databases

The quality of all modern planning methods of radio-systems depends to a great extent on the number and quality of databases being at the disposal to the designer. Due to that, the authors developing the *WTb* program package paid a particular attention just to databases. At present the authors have at their disposal several databases of quality in the electronic form used as a basis for the functioning of the *WTb* program package. They are:

- Digital database on the altitudes of the terrain of horizontal resolution 50*50m for the entire territory of the Republic of Serbia (more accurately for the entire territory of the ex- Yugoslavia).
- Digital database on the altitudes of the terrain of horizontal resolution 5*5m for the entire territory of Belgrade.
- A series of scanned maps (for the entire territory of the Republic of Serbia in the scale 1:25,000, the territory of the Republic of Montenegro in the scale 1:50,000, the territory of the Serbian Republic in the scale 1:300,000, for ex-Yugoslavia in the scale 1:500,000, for the territory of a larger territory of the city of Belgrade in the scale 1:150,000, 1:50,000 and 1:5,000, etc.).
- Digital clutter database for whole territory of Serbia; within it, it is possible to distinguish l6 different types of the usage of land: rural zone, many types of urbane milieus, forests, etc.
- The vector base of the streets of the city of Belgrade.
- The base of digitalized aero-photo pictures of a part of the city of Belgrade.
- A voluminous database of radio-transmitter locations.
- Database of antenna systems.
- And so on.

Figs 9, 10 and 11 illustrate the procedures of the integration of various program modules and the respective databases

Apart from the forementioned bases in the electronic form, the designers-authors have at their disposal a large base of topographic maps. It should be stressed that the authors had developed (and are still developing) the procedures and software tools to create indispensable digital databases (for example for forming clutter bases) in order to enhance the quality of the scheduled radio-systems at the optimal level.

THREE MOBILE OPERATORS USE *WTb* DATABASES:

- **TELEKOM SERBIA**
- **TELENOR (MONTENEGRO)**
- **MTEL (MONTENEGRO)**

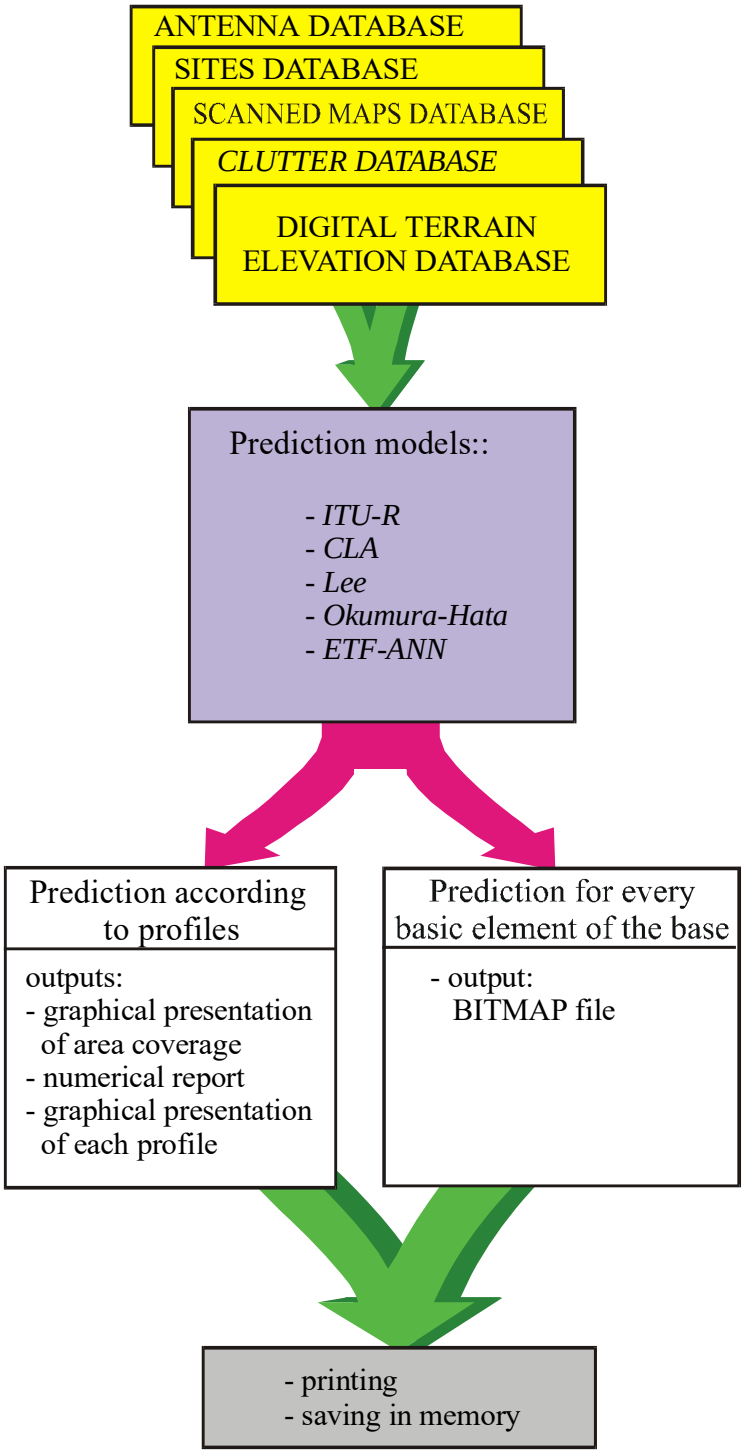

Fig. 9. The structure of the program module for predicting the level of the electrical field in a macrocell

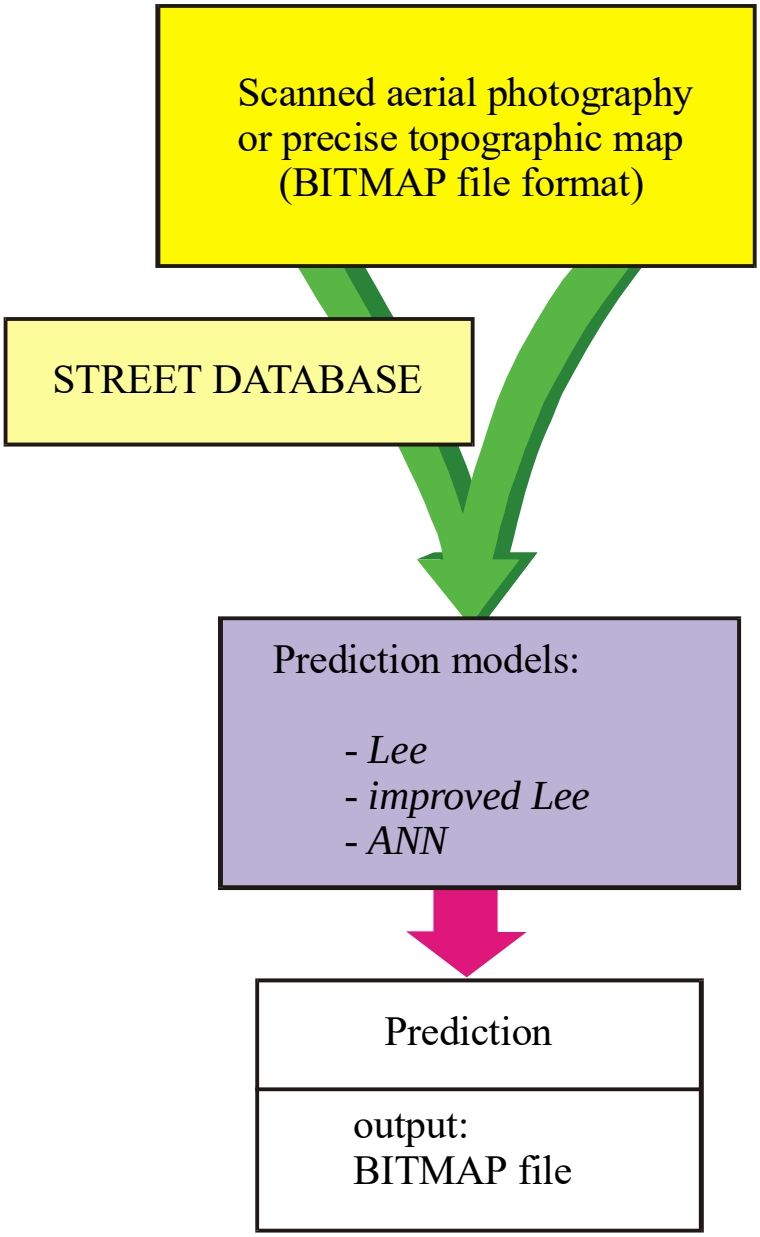

Fig. l0. The structure of the program module
for predicting the level of electrical field in a microcell

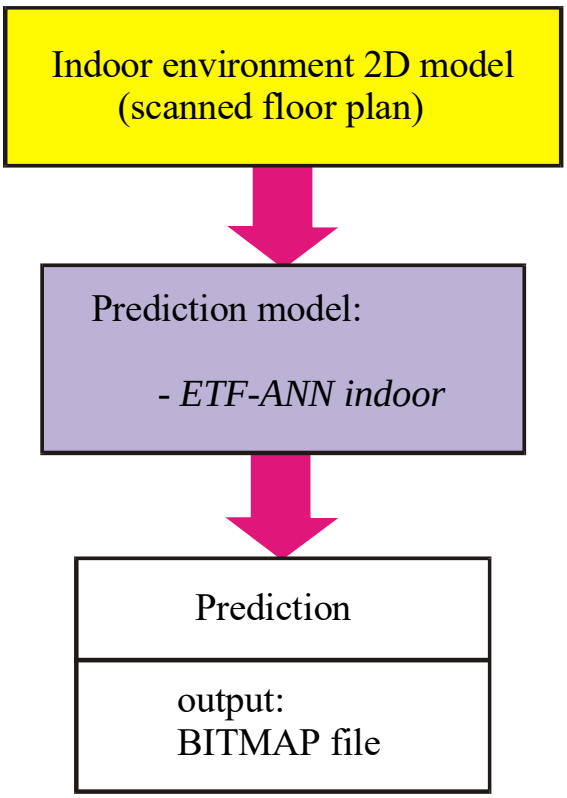

Fig. 11. The structure of the program module for predicting the level of electrical field in the indoor surrounding